

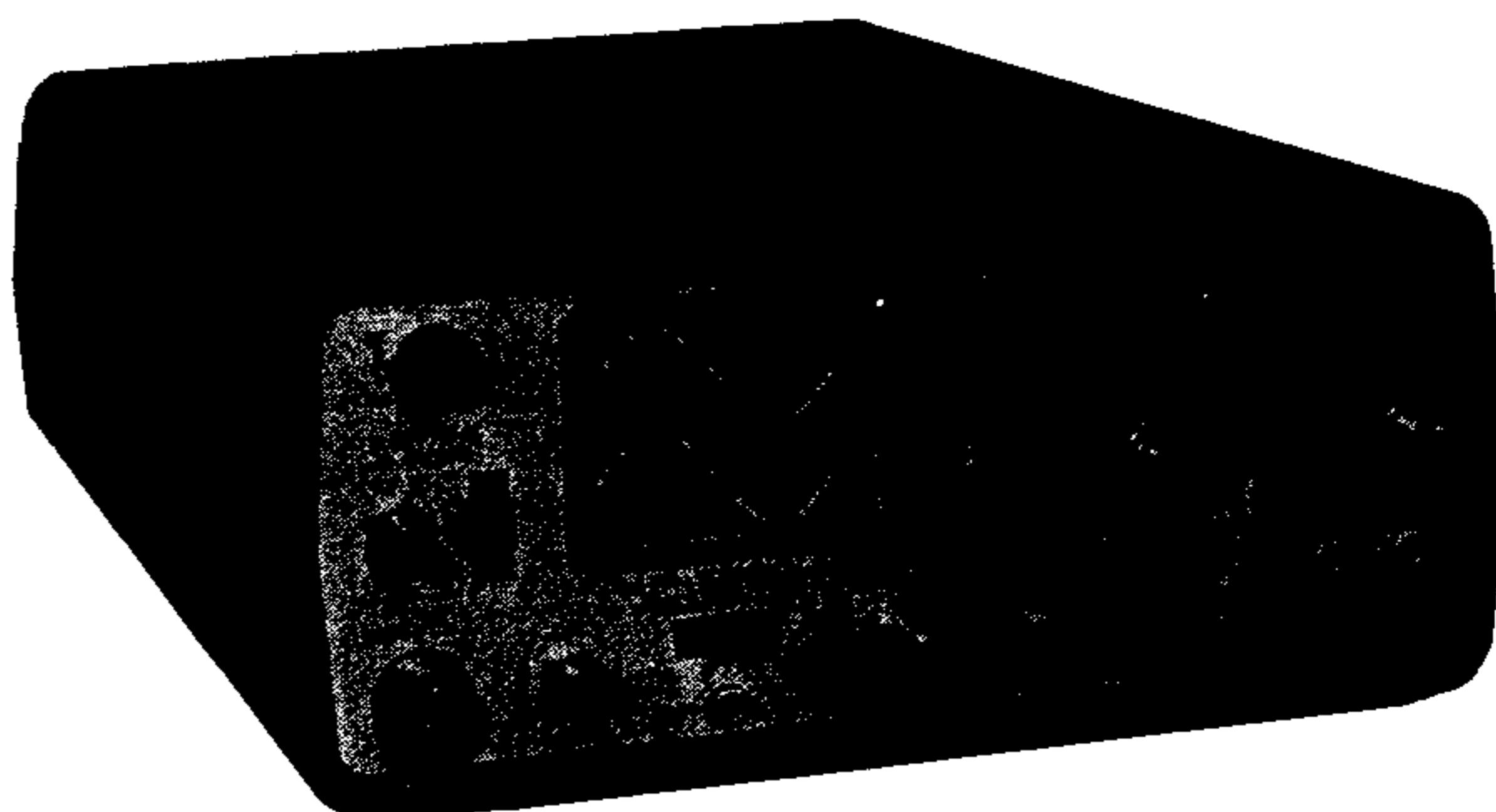
Battery 2 2.5AH 2V.
HAWKER

INSTRUCTION MANUAL

MS-215

MINISCOPE

0810 -0004
is right number



NON-LINEAR SYSTEMS

OSCILLOSCOPE PERFORMANCE IMPROVEMENT

Because of the wide bandwidth of the Miniscope, it is essential that extra care be employed in connecting the scope to the signal to be displayed. For most applications, using a 10:1 high impedance probe (NLS P/N 41-141 or equivalent) will produce the best results. The probe provides minimum loading of the signal while preserving the bandwidth of the scope.

If the signal amplitude is less than ten times the triggering sensitivity of the scope the 10:1 probe cannot be used. In order to preserve the bandwidth it is then necessary to use a BNC 50Ω coaxial feedthru (Pomona P/N 4119 or equivalent) connected to the scope input. The source must have an output matched to a 50Ω load and a 50Ω coaxial cable must be used between the source and the 50Ω feedthru.

The scope is shipped from the factory with one or two 1:1 shielded input cables with BNC connectors and alligator clips, depending upon whether it is single or dual trace. The bandwidth using the input cables is approximately 5 MHz.

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- c. Connect a 1 kΩ resistor between pins 1 & 3 of the CRT.
- d. Turn the intensity control to mid-range.
- 5-26. If there is no spot, then the CRT is defective. If there is a spot, check the horizontal and vertical amplifiers for balance. If no problem is found, then the problem is in the blanking circuitry.
- 5-27. TROUBLESHOOTING THE CALIBRATOR
- 5-28. If there is no 1V p-p calibrator output use signal tracing techniques to find where the signal is lost.

in the deflection amplifier output stage. If the voltage cannot be adjusted as specified, measure the voltage at the output of the first amplifier (collector of Q3 - figure 4-2). If it is within 0.01 VDC of ground, then the problem is in the second amplifier. If it is not as specified, then the problem is in the first amplifier. If the problem is incorrect gain use signal tracing techniques to locate the problem.

5-18. TROUBLESHOOTING THE HORIZONTAL AMPLIFIER

5-19. Use the same approach as is outlined in the Vertical Amplifier section.

5-20. TROUBLESHOOTING THE TIME BASE TRIGGER

5-21. If a problem exists in one or more positions of the Trigger Mode switch but not all, then the switch itself or associated networks are at fault. If a problem exists in all positions, then the fault lies with either the source follower (Q24 - figure 4-2), the Schmitt Trigger (U4 - figure 4-2) or slope selector (U14). Check the output of the source follower. If it exhibits approximately unity gain, the problem is in the trigger or slope selector. If the source follower does not have unity gain then it is the problem.

5-22. TROUBLESHOOTING THE TIME BASE GENERATOR.

5-23. If there is no horizontal sweep and the time base trigger is not at fault, then the time base generator is at fault. If the sweep works in some settings and not in others then the switching or the associated networks are at fault. If the sweep does not work at all, the constant current source can be tested by disconnecting the output collector lead (Q14 - figure 4-2) and measuring the current to ground. The gates in the astable multivibrator (U5 - figure 4-2), transmission gate (U6 - figure 4-2) and the flip-flop (U3 - figure 4-2) can be checked by examining their input versus output relationships.

5-24. TROUBLESHOOTING THE CATHODE-RAY TUBE.

WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be present.

5-25. If there is no spot or trace on the CRT:

- a. Check all the power supply voltages. (Refer to Table 4-1.)
- b. Short across the horizontal and vertical deflection plates (pins 6 & 7).

SECTION I

INTRODUCTION AND DESCRIPTION

1-1. GENERAL.

1-2. The NLS MS-215 Miniscope you have purchased is a fine electronic instrument with a great deal of measuring capability and excellent accuracy. Its design is modern, utilizing the latest in low powered integrated circuits, and it is packaged into the smallest practical size. The instrument fits into many briefcases and tool boxes with room to spare.

1-3. Operating characteristics have been chosen so that the MS-215 will make all of the measurements needed in servicing most electronic equipments. It is field-portable so its use is not restricted to the repair shop.

1-4. The Miniscope has a built-in ruggedness to withstand hard use. With only moderate care this fine, accurate electronic instrument will provide years and years of trouble-free service.

1-5. This manual is provided to acquaint you fully with your MS-215 Miniscope. You are urged to read this manual before you initially use your Miniscope. Two sections are most important. Reading the MS-215 specifications is important because:

a. You should be aware of maximum input ratings to avoid damage to the instrument.

b. By understanding the performance characteristics you will save yourself immeasurable time learning to operate the Miniscope and best utilize all of the outstanding capabilities it has.

1-6. Secondly, you should study for a few minutes the section which describes the location of controls, indicators and connectors. Familiarize yourself with the location and function of each. You will save both time and frustration in becoming acquainted with the MS-215 and getting it to do all of the many amazing and interesting things which it can do.

1-7. SPECIFICATIONS.

VERTICAL

Mode: CH1, CH2, CH1 & CH2 (Chopped) & CH1 & CH2 (Alternate)
(The following specifications apply to each channel.)

Bandwidth: DC to 15 MHz, ± 6 db @ 1 division deflection.*

Deflection Factor: 10 mV/div to 50V/div in 12 calibrated ranges. Accuracy is 3% of full scale with vernier in full clockwise position. Vernier provides continuously variable deflection factor between fixed ranges, uncalibrated.

Input Impedance: 1 megohm in parallel with 50 pF.

Maximum Input Voltage: 350V (DC + peak AC) provided DC component does not exceed 250V.

HORIZONTAL

Mode: Internal Time Base or External Horizontal, switch selectable. In the XY mode, vertical input is through CH1 and horizontal input through CH2.

Time Base: 0.1 μ Sec/div to 0.5 Sec/div in 21 calibrated ranges. Accuracy is 3% of full scale from 0.5 μ Sec to 0.5 Sec/div with vernier in full clockwise position. Accuracy is degraded from 0.1 μ Sec to 0.5 μ Sec/div. Vernier provides continuously variable settings between fixed ranges, uncalibrated.

Amplifier

Bandwidth: DC to 200 KHz (± 3 db).

Coupling: AC, DC or GND, switch selectable. Low frequency point on AC is 3 Hz.

Deflection Factor: 10 mV/div to 50V/div in 12 calibrated ranges. The ranges can be calibrated with the CH2 gain control.

Input Impedance: 1 M Ω in parallel with 50 pF.

Maximum Input Voltage: Same as vertical amplifier.

TRIGGER

Modes: Automatic (trigger is disabled, time base free runs), Internal (in the dual trace modes, the internal trigger source is CH1), External and Line (Line not functional when MS-215 operates on batteries). Input impedance is 1 megohm on External Trigger.

Slope: + or -, switch selectable.

*Typical 3 db point is 8 MHz @ 2 division deflection.

Typical maximum frequency for full scale (4 div) deflection is 2 MHz.

least one cell is faulty. Measure each cell. If any cell measures less than 1.8 VDC or greater than 2.4 VDC then that cell is faulty and should be replaced.

5-13. If the batteries are satisfactory then check the load current. With the charger/transformer unplugged and an ammeter in place of the fuse, measure the operating current drain on the batteries with the PWR switch on. It should be less than 700 mA DC. If not, then one of the secondary windings of the DC/DC converter is probably overloaded and one or more of its output voltages will measure low.

5-14. If all the above checks do not locate the problem then the charging circuitry is at fault. After giving the batteries a full charge (see Operating section of manual) measure the battery voltage from the fuse to ground. It should be +7.2 VDC ($\pm .1$ VDC) before the scope is turned on. If it is not, then the charging circuitry is faulty. Too high a voltage will overcharge the batteries and reduce their life. Too low a voltage will not fully charge the batteries and the scope will operate only a short time from the batteries alone. The charge regulator may just need readjusting (see Calibration section) or there may be a faulty component.

5-15. If the scope will not run continuously from the charger/transformer, measure the line voltage. It should be within 105 VAC to 125 VAC with a 115 VAC charger/transformer and 210 VAC to 250 VAC with a 230 VAC charger/transformer. If the line voltage is satisfactory, go through the procedure listed for short operating time from batteries. Finally, with the battery voltage less than +6.4 VDC measured from the fuse to ground, measure the charge current by inserting an ammeter in place of the fuse and plugging in the charger/transformer with the scope off (if necessary, operate the meter from the batteries alone to achieve this voltage). The current should measure greater than 700 mA DC.

NOTE

The charge current is related to the battery voltage, rising as the battery voltage drops. If the current is less than 700 mA DC, the charging circuitry is faulty.

5-16. TROUBLESHOOTING THE VERTICAL AMPLIFIER

5-17. With the vertical input grounded, if the trace or spot is visible when the vertical deflection plates (pins 9 & 11) are shorted together and disappears when the short is removed, the vertical amplifier is in a state of DC unbalance. To determine where the problem is measure the differential voltage at the output of the second amplifier (pins 7 and 8 of U1 - figure 4-2). If it can be adjusted to ± 2 VDC with the front panel vertical position control, then the problem is

- d. Time Base Trigger
- e. Time Base Generator
- f. Cathode Ray Tube
- g. Calibrator

5-9. The first circuit to check for any type of trouble is the Power Supply, (See table 4-1). All the other circuits in the instrument are dependent on the proper operation of the power supply circuitry. If all the power supply voltages are correct then the nature of the symptom should direct you to the circuit which contains the trouble. For example, if the trace on the CRT appears normal in the horizontal direction but not in the vertical then the problem is most likely in the vertical amplifier.

WARNING

Use extreme caution in performing the following steps as dangerously high voltages will be present.

5-10. TROUBLESHOOTING THE POWER SUPPLY.

5-11. If the power indicator does not light and there is no trace when operating from batteries alone, but there is an erratic appearing trace when operating from the charger/transformer then the problem is very likely a blown fuse. The fuse (F2 - figure 4-2), if not defective, will measure less than 0.1 ohm. If after replacement the fuse blows again, then the problem is in the +5.75 VDC regulator between the batteries and the DC/DC converter. The +5.75 VDC regulator should use less than 50 mA DC unloaded. The regulator can be unloaded by cutting the printed circuit line between it and the DC/DC converter. Two extra holes have been provided in the printed circuit for a jumper to repair the cut. If the regulator is functioning properly, then check the +5 VDC line on the main board and the rectifiers and loads on the secondaries of the DC/DC converter. Also check the switching transistors on the input of the DC/DC converter. If these tests do not uncover a fault, the DC/DC converter transformer is probably defective.

5-12. If the MS-215 will not operate on batteries alone for more than two hours after receiving a full charge (see Operation section of this manual), then either the batteries are weak, there is an excessive load on the batteries or the charging circuitry is at fault. First check the batteries. From the fuse to ground the battery voltage should measure between +5.8 VDC and +7.3 VDC regardless of whether the scope is operating from the batteries or not. Measure the battery voltage during each of these modes. If the voltage is outside the limits, then at

Coupling: AC

Sensitivity: Less than 1 div for internal trigger and less than 1 volt for external trigger.

Level: Trigger Level control permits continuous adjustment of trigger point in all modes except Auto.

CALIBRATOR: A square-wave signal of 1 voltp-p is provided. Voltage accuracy is $\pm 5\%$, frequency is approximately 1 KHz.

DISPLAY

Graticule: 4 x 5 div, each division is 0.25 inch.

CRT: Bluish-white phosphor, medium persistence. CRT uses low power filament for low battery drain.

POWER SOURCES

Internal: Three sealed, rechargeable lead-acid cells. Operating time using fully charged cells is approximately three hours. Charging circuitry is integral and functions when MS-215 is connected to power line through plug-in transformer (supplied with each MS-215). Battery charge time with instrument non-operating is 16 hours.

External: Operates continuously from 115 vac source 50 - 400 Hz when connected via plug-in transformer. Alternate transformer for 230 vac is available. Power consumption from AC line is less than 15 watts.

ENVIRONMENT

Operating Temperature: 0° to 40° C.

Shock and Vibration: Will withstand normal shock and vibration encountered in commercial shipping and handling.

PHYSICAL MEASUREMENTS

Size: 2.9" H x 6.4" W x 8.0" D. (73.7 mm x 162.6 mm x 203.2 mm)

Weight: 3 lbs (1.36 kg) with batteries.

SECTION V
MAINTENANCE

5-1. CLEANING.

5-2. The outer surfaces of the MS-215 will require cleaning from time to time. Use a warm water and detergent solution with a cloth and/or brush. Be careful not to scratch the graticule. Since there are no ventilating holes in the case of the MS-215 the circuitry probably will not require cleaning. However, in a severely dusty environment blow off the dirt accumulated inside the case with filtered compressed air. If this is not available use a brush and a vacuum cleaner. Use care so as not to upset the settings of the calibration potentiometers. If the above methods are not sufficiently effective, use a Freon (R) base solvent with a brush. Do not use a vapor degreaser as it will damage the potentiometers.

5-3. VISUAL INSPECTION

5-4. After every few months of use visually inspect the oscilloscope for loose or broken connections, loose screws, heat-damaged components or leaking batteries. If anything amiss is noted, the appropriate corrective action should be taken. In the case of over-heated parts, it is likely that the problem is not with the part that is overheated. When replacing an overheated component make sure the associated circuitry is functioning properly. Otherwise another overheated component may result.

5-5. TROUBLESHOOTING PROCEDURE.

5-6. Before attempting to troubleshoot the MS-215 make sure that any apparent trouble is actually due to a malfunction within the instrument rather than improper control settings. Instructions for the operation of the oscilloscope are contained in the Operation Instructions section of this manual.

5-7. CIRCUIT TROUBLESHOOTING

5-8. The MS-215 consists of seven main circuits. These are:

- a. Power Supply
- b. Vertical Amplifiers
- c. Horizontal Amplifier

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DIFFERENCE DATA
MS-215 S/N's 1 thru 3699

SECTION II
OPERATION

CHARGING CIRCUIT CALIBRATION.

1. If your instrument has not been so modified, remove the one ampere fuse (F1) on bottom of rear board.
2. Solder a jumper into fuse sockets; ensure clean and firm solder joints.
3. Follow procedure set forth in paragraph 4-6.

2-1. GENERAL.

2-2. This section provides identification of controls, indicators and connectors which are used to operate and monitor the functional operation of the MS-215 (figure 2-1). Also provided are detailed descriptions and instructions for operation of the controls.

2-3. OPERATING INSTRUCTIONS.

2-4. In the following instructions the number in parenthesis following the name of a control, indicator or connector relates to the numerical callout of that control, indicator or connector shown in figure 2-1.

2-5. TURN-ON.

a. Decide the power source to be used. Choices are:

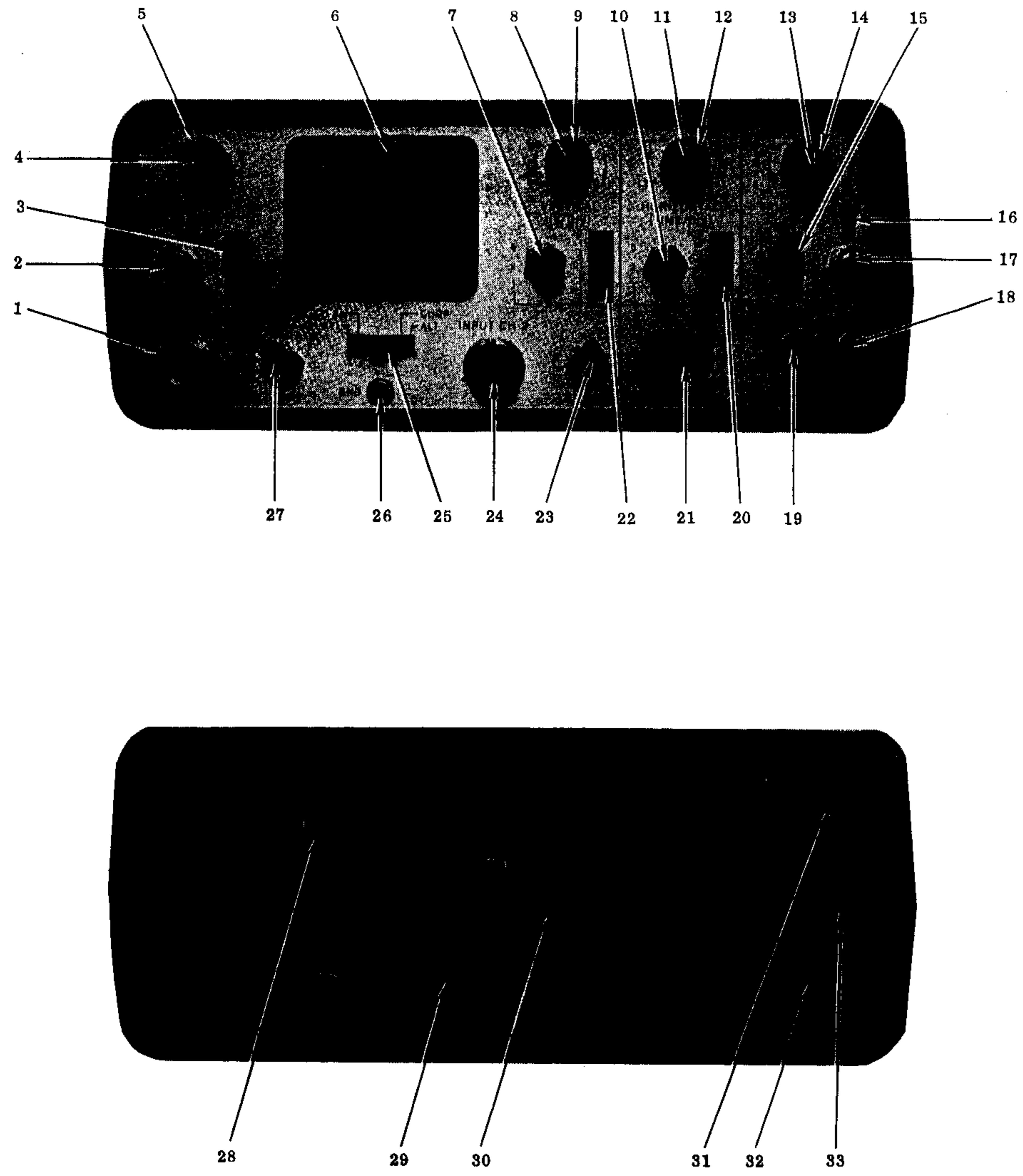
1. Internal batteries - be sure that the batteries have sufficient charge to operate the scope by checking to see if the power indicator LED (16) is illuminated.
2. For 115 VAC operation, utilize a 115 VAC charger/transformer unit.
3. For 230 VAC operation, utilize a 230 VAC charger/transformer unit.

b. After turning on the PWR switch (18), the warm-up time is less than five seconds. If the batteries are completely run down at turn-on, it will take approximately 60 minutes (PWR switch off) to charge them enough to operate the Miniscope.

2-6. BEAM LOCATION AND TRACE GENERATION.

a. Adjust the following:

1. INTENSITY control (30) to maximum.
2. Horizontal position (LFT-RT) control (11) to center.
3. CH1 & CH2 vertical position (UP-DN) controls (4 & 8) to centers.



4-15. TIME BASE LOW FREQUENCY.

- Use internal trigger mode and AC vertical coupling. Set time/DIV to 5 μ s/DIV with time vernier in CAL (CW) position.
- Connect a 100 Hz square wave frequency-calibrated to 1% accuracy to vertical input. Center trace. An inexpensive square wave generator may be used if monitored by an NLS FM-7 Frequency Meter. Input voltage to the FM-7 should not exceed 0.7 volt peak-to-peak.
- Adjust R69 (figure 4-2) and horizontal position control so that trace is approximately 1/32 inch longer than five divisions of graticule in horizontal direction.
- Adjust R93 (figure 4-2) and horizontal position control for best coincidence of vertical lines of square wave trace with vertical lines of graticule.

4-16. TIME BASE HIGH FREQUENCY

- Preparation is the same as in paragraph 3-15 except vertical input frequency is 100 KHz and time/DIV is 5 μ s/DIV.
- Adjust C23 (figure 4-2) and horizontal position control for best coincidence of vertical lines of square wave trace with vertical lines of graticule.

4-17. RETRACE BLANKING ADJUSTMENT

- Using a positive triggered sweep and AC input coupling, connect a 100 KHz square wave vertical input. Set time/DIV controls to 5 μ s/DIV.
- Turn INTENSITY control to maximum.
- Adjust R134 (figure 4-1) so that retrace just appears at top and/or bottom of square wave. Note position of R134.
- Readjust R134 so that trace disappears. Note position of R134.
- Set R134 to a position halfway between positions noted in c. and d. above so that a complete bright trace is obtained with no retrace and no bright spot or vertical line at beginning.

Figure 2-1. Controls, Indicators and Connectors (Sheet 1 of 2)

- d. Adjust CH1 VERTICAL BALANCE control (on rear panel) so that trace coincides with central horizontal line of graticule.
- e. Change V/DIV controls to 50 V/DIV and repeat steps b. thru d. until trace does not move from central line at 50 V/DIV or .01 V/DIV. When this is completed there will be less than 1/3 division shift in trace for other V/DIV settings.
- f. Repeat above steps for CH 2 amplifier.

4-12. VERTICAL AMPLIFIER LOW FREQUENCY GAIN.

- a. Using AC vertical input coupling and internal triggered mode, connect calibrator output to CH2 vertical input of Miniscope. Set vertical V/DIV controls to .5V/DIV. Center trace vertically. Set vernier to CAL (CW).
- b. Adjust R51 (figure 4-2) so that trace amplitude is exactly two graticule divisions high.
- c. Repeat step 4-12a using CH1.
- d. Repeat step 4-12b using R27 (figure 4-2).

4-13. VERTICAL AMPLIFIER HI FREQUENCY GAIN.

- a. Using CH2 AC vertical input coupling and internal triggered mode, connect a 100 KHz square wave to vertical input. Set vertical V/DIV to .5V/DIV. Set vernier to CAL (CW). Set Horizontal (Time/DIV) switches to $5 \mu s$ /DIV.
- b. Adjust C11 (figure 4-2) until truest display of a square wave is obtained.

4-14. INPUT ATTENUATOR COMPENSATION.

- a. Connect a square wave source having an output capability of 2V P-P or greater at 10 KHz to CH2 vertical input. Use triggered mode, AC coupling and set V/DIV controls to 1V/DIV. Adjust vernier to obtain two divisions of vertical deflection.
- b. Adjust C202 (figure 4-2) until the truest display of a square wave two divisions high is obtained.
- c. Repeat 4-14a using CH1.
- d. Repeat 4-14b using C2 (figure 4-2).

LEGEND	
1. CH1 Vertical Input Connector	18. Calibrator Output Jack
2. CH1 Vertical V/Div Multiplier Select	19. External Trigger Input Jack
3. CH1 Vertical V/Div Range Select	20. Time Base Range Select
4. CH1 Vertical Position Control	21. Time Base Units Select
5. CH1 Vertical V/Div Vernier Control	22. CH2 Vertical V/Div Range Select
6. Graticulated Viewing Screen	23. CH2 Vertical AC, GND, DC Coupling Select
7. CH2 Vertical V/Div Multiplier Select	24. CH2 Vertical Input Connector
8. CH2 Vertical Position Control	25. Vertical Display Mode Select
9. CH2 Vertical V/Div Vernier Control	26. Ground Jack
10. Time Base Multiplier Select	27. CH1 Vertical AC, GND, DC Coupling Select
11. Horizontal Position Control	28. Charger Input Jack
12. Time Base Vernier Control	29. CH2 Vertical Balance Control
13. Trigger Slope Select	30. Intensity Control
14. Trigger Level Control	31. Focus Control
15. Trigger Select	32. CH1 Vertical Balance Control
16. Power Indicator	33. Astigmatism Control
17. Power Switch	

Figure 2-1. Controls, Indicators and Connectors (Sheet 2 of 2)

- 4. Select GND positions for input coupling switches (23 & 27).
- 5. Select mS or μ S (21).
- 6. Select AUTO Trigger (15).
- 7. Select CHOP or ALT (25) vertical display mode.
- b. Rotate the horizontal and vertical position controls to locate the traces and position them to the desired locations on the graticule (6).
- c. Adjust the ASTIGMATISM (33), INTENSITY (30) and FOCUS (31) controls to give the sharpest and clearest traces possible.

2-7. SINGLE TRACE SIGNAL DISPLAY. After setting up the Miniscope to display the two traces as set forth in paragraph 2-6, connect an input signal to the CH 1 input connector (1) using either a 1:1 cable or a 10:1 probe. Then proceed as follows:

- a. Set the CH 1 input coupling switch (27) to AC.
- b. Set the vertical mode selector switch (25) to CH 1.

- c. Set the vertical (V/DIV) switches (2 & 3) to 5 x 10 (minimum sensitivity).
- d. Observe height of the display.
- e. Increase the sensitivity of the scope by changing the settings of the vertical (V/DIV) switches (2 & 3) until the height of the display is one to three divisions.
- f. Change the trigger selector switch (15) from AUTO to INT and adjust the trigger level control (14) so that the trace reappears.
- g. Adjust the horizontal (TIME/DIV) switches (10, 20 & 21) to obtain a display of one to three periods of the waveform.
- h. Readjust the vertical, horizontal and trigger controls, if desired, to expand or compress the waveform or to start it at different point in its cycle.

NOTE

A single trace display may also be obtained using the CH 2 input and controls in a similar fashion.

2-8. DUAL TRACE OPERATION. Two harmonically related signals can be simultaneously displayed by the MS-215. Examples are the input and output waveforms of filters, attenuators, amplifiers, flip-flops, counters, shift registers, etc. The signal to be used as the internal trigger source must be connected to CH 1. If an external trigger source is used then channel selection is immaterial. The same procedure for selecting the vertical and horizontal control settings as outlined in the single trace section apply here except that both CH 1 & CH 2 must be adjusted, and the CHOP or ALT modes must be selected. To obtain the clearest display, it is usually best to select the ALT mode for frequencies above 20 KHz and the CHOP mode for lower frequencies. Remember that the trigger source (time reference) for each trace is always the same for both modes so that time or phase comparisons between traces can always be made.

2-9. TRIGGERING.

2-10. The SLOPE (13) and LEVEL (14) controls are used to set the point on a waveform at which the Miniscope is triggered and the trace is started. Four trigger modes are provided, giving the capability to view and make measurements on a wide variety of waveforms. Time base controls, multiplier, 5-2-1 (10),

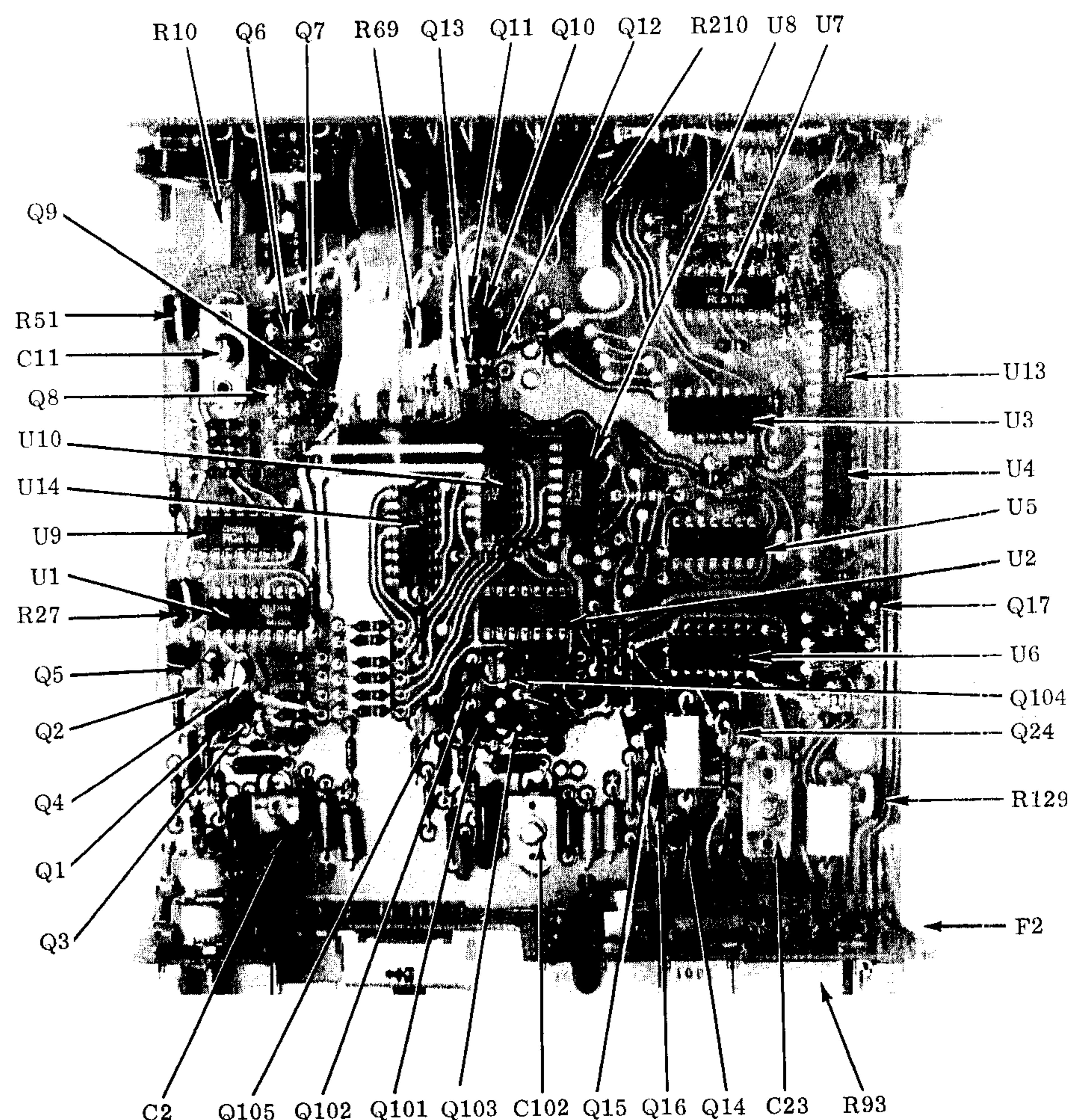


Figure 4-2. Component Location - Main Board

3-16. CALIBRATOR

3-17. The 1V P-P calibrated output signal, available on the front panel, is derived from an internal frequency after being squared up by a flip-flop (1/2 U 14). The signal is useful as a check on the calibration of the vertical amplifier, in setting the frequency compensation of high input impedance probes, or as a test signal source for external circuitry. The frequency is typically 1 KHz and the duty cycle is approximately 50%. It is a bipolar signal referenced to ground.

3-18. POWER SUPPLY

3-19. All of the supply voltages required by the circuits in the MS-215 previously described in this section are generated by a DC/DC converter. The +75 VDC supply employs a full wave bridge. The -750 VDC supply employs a voltage doubler circuit. The remaining supplies use half-wave rectifiers. The primary of the DC/DC converter transformer is connected to two power transistors (Q22 & Q23) in such a manner that the circuit self-oscillates in the saturating mode. An RC network is connected across the primary to suppress the non-saturated mode. Since all of the loads on the secondaries are fairly constant, regulating the input voltage to the converter simultaneously regulates all the outputs. The input to the converter is provided by the +5.75 VDC regulator. The series pass transistor (Q20) is driven by an inverter (Q19) which is controlled by a 3-terminal shunt regulator (VR2) through the front-panel power indicator LED (CR12). VR2 has an internal reference of approximately +2.75 VDC. When the input to the +5.75 VDC regulator drops below +5.7 VDC, the regulator shuts down completely and the indicator goes out, indicating insufficient battery voltage to maintain proper operation of the scope. This unloads the batteries and protects them from excessive drain. As soon as it is noticed that the power indicator has gone out, the power switch should be turned off. The batteries should then be given a full recharge.

3-20. The batteries are charged from the line via an outlet-mounted charger/transformer which plugs into the rear of the MS-215 through a coaxial power adapter. The output of the charger/transformer is full-wave rectified in the oscilloscope and charges the batteries through a series pass transistor (Q18). Q18 is controlled by the 3-terminal shunt-regulator (VR1). The charge regulator shuts off when the batteries reach +7.2 VDC (± 0.1 VDC), thus protecting the batteries from overcharge.

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

3-2. The MS-215 is a small, portable, rechargeable-battery powered dual trace oscilloscope. The circuitry uses mainly integrated circuits of the C-MOS or low-power Schottky types. A low filament power CRT is also used to reduce drain on batteries. The MS-215 has four vertical deflection modes:

- a. CH 1
- b. CH 2
- c. CH 1 & CH 2, chopped
- d. CH 1 & CH 2, alternately

3-3. The source for internal triggering of the horizontal sweep during the four vertical modes is:

- a. CH 1
- b. CH 2
- c. CH 1
- d. CH 1

3-4. Besides internal triggering, the scope can also be triggered from an external signal, the power line, or the horizontal sweep will free run if there is no triggering sources available. In following the various internal circuit descriptions below, refer to figure 3-1 - see also figures 4-1 and 4-2 for component location.

3-5. VERTICAL AMPLIFIER

3-6. There are three amplifiers in cascade which make up the CH 1 vertical amplifier. The first amplifier is a FET input operational amplifier (Q1, Q2, Q3) connected as a unity gain, non-inverting follower. The input to this amplifier is either direct, AC coupled or grounded depending on the position the front-panel toggle switch. Also a 100:1 attenuator is inserted between the input signal and the amplifier in the 1 and 10 position of the front-panel (vertical V/DIV) slide switch. The output of the first amplifier connects to an attenuator with divisions of 1:1, 2:1 or 5:1 depending on the front-panel (vertical V/DIV) toggle switch. An additional division of 10:1 in the output of the first amplifier is inserted when the front-panel (vertical V/DIV) slide switch is in the .1 or 10 positions. The front-panel variable gain control is also connected in series with these attenuators. The output of the attenuators is connected to an emitter follower (Q4). The front-panel vertical position control is connected to another emitter follower (Q5). The outputs of the emitter followers are connected to the inputs of a second amplifier. The second amplifier is a differential input/differential output monolithic bi-polar

amplifier (U1) with a gain of about 100:1. The outputs of this amplifier are connected to the inputs of the vertical deflection amplifier through C-MOS solid state analog transmission gates (1/2 U9). The vertical deflection amplifier consists of a differential bi-polar pair (Q6, Q7) with the vertical deflection plates of the CRT connected to the collectors and constant current sources (Q8, Q9) connected to emitters.

3-7. The CH 2 vertical amplifier is the same as the CH 1 amplifier except the circuit symbols are different.

3-8. HORIZONTAL AMPLIFIER

3-9. The horizontal deflection amplifier (Q10, Q11, Q12, Q13) is the same as the vertical deflection amplifier except it has a smaller bandwidth and the horizontal deflection plates are connected to its output. In the (XY) operating mode the inputs to the horizontal deflection amplifier come from the outputs of the second amplifier of the CH 2 vertical amplifier. In the triggered sweep operating mode, the inputs to the horizontal deflection amplifier come from the horizontal position control and the output of a N-channel junction FET source follower (Q24) which is connected to the time base generator. The connections to the horizontal deflection amplifier inputs are made by C-MOS solid state analog transmission gates (U8).

3-10. TIME BASE GENERATOR

3-11. The time base generator is composed of five sections: a front-panel controllable constant current source (Q14, Q15, Q16), the capacitive load on the constant current source (C21, C22, C23), an astable multivibrator (1/2 U 5), a flip-flop (1/2 U 3), and a solid state switch (U6). In the initial state the capacitor is grounded through the solid state switch. A pulse from the trigger circuit flips the flip-flop. The switch lets the capacitor charge positively in a linear ramp at a rate determined by the constant current and the value of the capacitor. When the ramp reaches a level determined by the threshold of the astable multivibrator the multivibrator generates a pulse which flips the flip-flop back to its initial state. This causes the capacitor to be discharged rapidly by the solid state switch. The length of the multivibrator pulse is long enough to permit the complete discharge of the capacitor. The flip-flop is prevented from being triggered before the capacitor is discharged by a gate (1/4 U 3) between the flip-flop and the time base trigger.

3-12. TIME BASE TRIGGER

3-13. The time base trigger is composed of a Schmitt trigger (1/2 U4), an inverter (1/4 U4) and an input buffer (Q17). The input buffer is an N-channel junction FET connected as a source follower. Its input can be connected to the output of the second vertical amplifier for synchronization of the time base to the vertical input signal (internal trigger). It can be connected to an external source for synchronization of the time base to some other signal (external trigger). It can be disconnected when there is no signal to synchronize on so that the time base will free run (auto trigger). It can also be connected to a line frequency signal derived from the output of the charger/transformer (line trigger). These four sources are selectable with the front-panel trigger slide switch. The output of the buffer (Q17) is connected to the input of the Schmitt trigger which is connected to an inverter. Either the Schmitt trigger output or its inverse is connected to the time base generator depending upon the setting of the front-panel trigger slope switch.

3-14. CATHODE-RAY TUBE.

3-15. The deflection plates of the CRT are connected to the outputs of appropriate deflection amplifiers. At zero deflection the vertical plates are at approximately +35V with respect to ground and the horizontal plates are at approximately +45V. The astigmatism control element (pin 12) is connected to the wiper of a potentiometer between -6 VDC and +95 VDC. The wiper voltage for the best display can fall anywhere within those extremes, depending on the tube. The focus element of the CRT (pin 4) is tied to the wiper of a potentiometer which is one of a series of resistors from the cathode of the CRT to ground. The voltage at the wiper for display will be anywhere from 50 VDC to 200 VDC above the cathode of the CRT. The screen element of the CRT (pins 10 & 13) is connected to a fixed divider and is nominally 50 VDC above ground. The CRT has a directly heated cathode. The heater current is nominally 60 mA and is about 750 VDC below ground. The intensity control grid (pin 3) is connected to the wiper of a potentiometer which is connected to a flip-flop (1/2 U11). The flip-flop is powered by a nominal 13 VDC supply referenced to the cathode of the CRT at -750 VDC. The flip-flop is capacitively coupled to the flip-flop (U3) in the time base generator and follows its state synchronously in the linear sweep mode. In one state of the flip-flop the grid cuts off the beam current, thus preventing the retrace from appearing in the display. In the other state a beam current is obtained which depends on the setting of the intensity control. In the external horizontal input mode, the time base generator is disabled and a third capacitively-coupled connection to the blanking flip-flop turns the beam on continuously.

- 3. Batteries not charged.
- 4. No input signal in triggered mode.
- 5. Insufficient amplitude signal to trigger on.
- 6. Trigger level control not adjusted properly.
- b. Beam spot only.
 - 1. Trigger level control set too low.
 - 2. No trigger present in external trigger mode.
 - 3. External horizontal input (CH 2 (X)) selected with no horizontal input.
 - 4. External horizontal input (CH 2 (X)) selected with CH 1 & CH 2 inputs at GND.
 - 5. External horizontal input (CH 2 (X)) selected with CH 1 & CH 2 V/DIV settings too high.
- c. No vertical deflection.
 - 1. Vertical input coupling switch in GND position.
 - 2. No vertical input signal; check leads.
 - 3. Vertical V/DIV settings too high.
- d. Inaccurate measurements of voltage or time.
 - 1. Vernier not set at CAL position.
- e. Trace will not synchronize.
 - 1. Incorrect trigger mode, generally.
 - 2. Non-repetitive or unstable input frequency.
 - 3. Automatic trigger mode selected.
 - 4. Input signal not derived from the line in the LINE mode.
 - 5. Vertical input signal not derived from the same source as the trigger input, in the external trigger mode.

SECTION IV
CALIBRATION

4-1. INTRODUCTION

4-2. Instrument must be functional in all modes before calibration. The calibration will be invalid if the instrument is partially inoperative.

4-3. EQUIPMENT REQUIRED

- a. Digital Multimeter, NLS Model LM-3.5A, or equivalent
- b. Oscilloscope, with vertical deflection calibrated to 1% or better
- c. Waveform Generator-1Hz to 100KHz, variable amplitude square and sine wave capability
- d. Frequency Meter, NLS FM-7 or equivalent
- e. DC Voltage Source, 6.3V @ 1 Amp

WARNING

Dangerous voltages are present at several locations in the MS-215. Because it is battery-operated, such voltages will be present even when the instrument is disconnected from the AC power line, if the PWR switch is in the ON position. Exercise caution and use an all-plastic screw-driver for all adjustments.

4-4. INITIAL PREPARATION

- a. Set PWR switch to OFF position. Remove screw from bottom of the case.
- b. Gently slide instrument chassis out of case.
- c. Insert plug of transformer cord into instrument and plug transformer into the appropriate power source.
- d. Set PWR switch to ON position.

NOTE

If the batteries are fully charged, allow 30 seconds for instrument warmup; if batteries are completely run down, turn the scope off and allow approximately 60 minutes of charging time before turning the scope back on.

4-5. PROCEDURE.

4-6. CHARGING CIRCUIT - S/N 3700 & ON. (For prior S/N's see page 4-8.)

- a. Remove the two ampere fuse (F2) on front board near PWR switch.
- b. Using another oscilloscope with vertical deflection calibrated to 1% or better, connect its ground to MS-215 ground and its input to upper fuse terminal. Also connect a $2\text{ k}\Omega$ resistor from upper fuse terminal to ground. Adjust R112 (figure 4-1) until peak-to-peak voltage measures 7.2 VDC.
- c. Disconnect test oscilloscope.

4-7. +5.75 VDC REGULATOR AND BATTERY DISCHARGE CUTOFF.

- a. Disconnect transformer.
- b. Connect a source of +6.3 VDC to upper fuse terminal.
- c. Set PWR switch to ON.
- d. Check to see that red power indicator LED on front panel is illuminated. If not, adjust R120 (figure 4-1) CCW and turn PWR switch off and then on again.

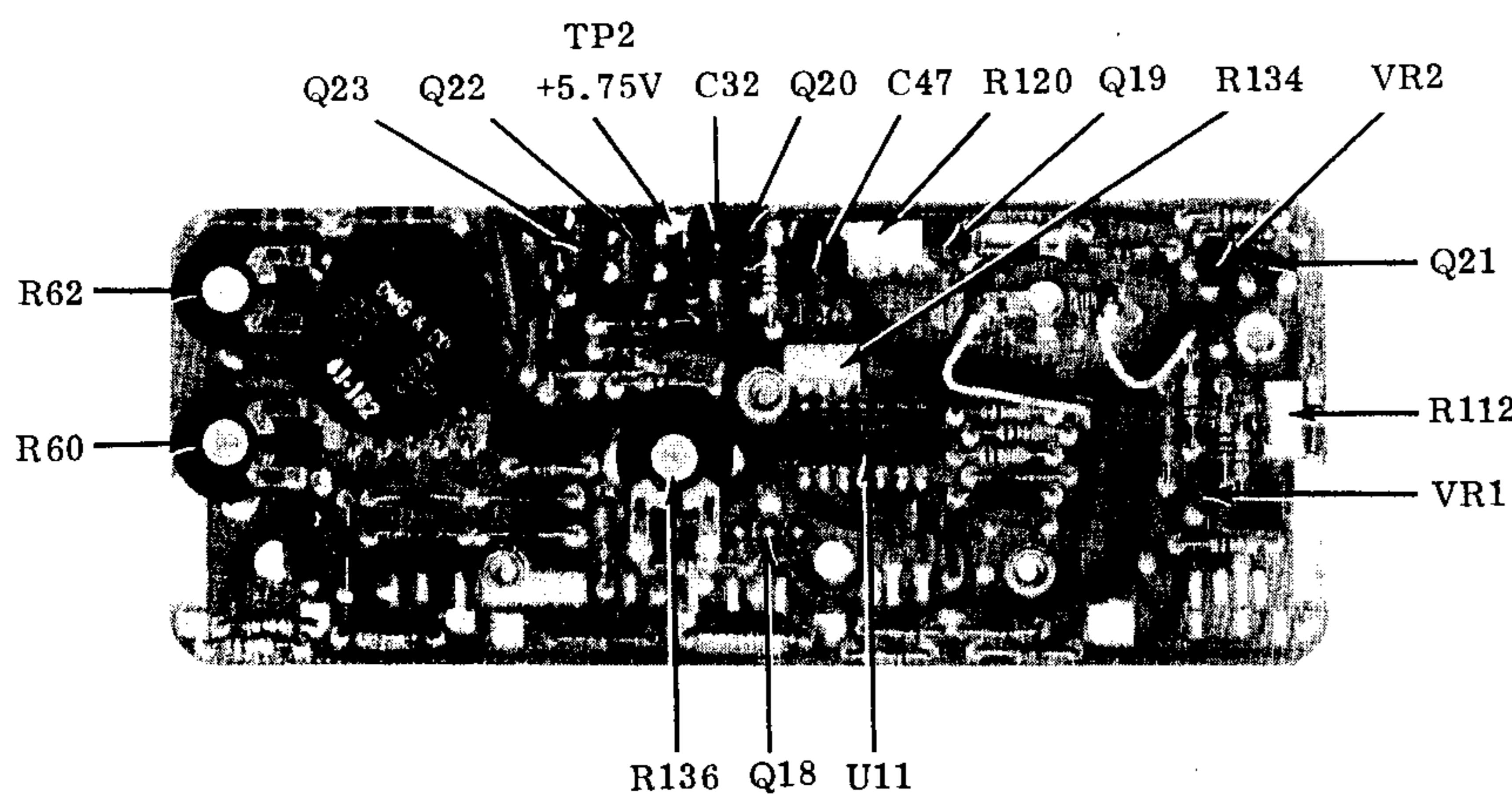


Figure 4-1. Component Location - Rear Board

MS-215 and into an active power outlet at all times. The batteries will reach their maximum charge overnight when the power switch is off. Keeping the batteries as near to full charge as possible will help preserve their operating life. If the instrument is run from line voltage continuously, the batteries will level out at approximately one-half full charge.

- b. When it is desired to operate the scope from the batteries alone, first be sure that they are fully charged so that maximum operating life can be obtained. If not fully charged, plug the charger into the rear of the MS-215 and into an active power outlet. Leave the power switch off until you are ready to use the instrument. The batteries will reach their maximum charge in 16 hours. Leaving the batteries on charge for a longer period of time will not harm them. The scope's charging circuitry will automatically cut off when the batteries reach full charge and will continue to keep them at full charge.
- c. At full charge the batteries will provide three hours of continuous operation. Take advantage of the instrument's short warm-up time and save the batteries - shut it off when you are not actually looking at it.
- d. When the batteries have run down, the power indicator lamp will go out. When this occurs, shut off the power and put the scope back on charge as soon as possible. It is better to give them a full charge before using the instrument again; this will help to preserve their capacity.

CAUTION

Do not leave PWR switch on when power indicator light goes out. Do not leave the instrument unattended with the PWR switch on as complete discharge of the batteries may take place. If this occurs, the batteries may be damaged and may not be rechargeable.

2-25. OPERATIONAL TROUBLESHOOTING.

- a. No trace.
 1. Intensity control turned down.
 2. X or Y position controls not centered.

2-17. MEASUREMENTS.

2-18. When the vernier controls for time (12) and vertical (5 & 9) amplitude are rotated fully clockwise to the CAL position, measurements of voltage, time frequency and phase can be made with an accuracy of 3%.

2-19. With the vertical V/DIV verniers (5 & 9) in the CAL position, the V/DIV set in on the multiplier (2 & 7) and range (3 & 22) controls are accurately calibrated vertically on the graticulated display screen for AC and DC voltage amplitudes.

2-20. With the horizontal (TIME/DIV) vernier (12) set at CAL, the time base settings on the horizontal multiplier (10), range (20) and units (21) controls are accurately calibrated horizontally on the graticulated viewing screen. Time and period (1/freq) can be read directly. By using an external trigger, or by the external switching of stable input waveforms, phase may be accurately measured.

2-21. XY OPERATION. When it is desired to control the horizontal deflection of the display from a source other than the internal linear time base of the MS-215, then the XY mode of operation must be used. This mode is selected by placing the vertical mode switch in the CH 1 (Y) position and the horizontal mode switch in the CH 2 (X) position. This provides vertical control of the trace by the CH 1 circuitry and horizontal control by the CH 2 circuitry. In this manner Lissajous patterns can be displayed for simultaneous phase and gain measurements, signal synchronization, etc.

2-22. The XY mode transfers all horizontal controls to the CH 2 circuits. The normal horizontal controls are disabled as are the trigger circuits. Also the CAL position of the CH 2 variable gain control will not provide a truly calibrated deflection. If calibrated horizontal measurements are necessary, apply the 1V P-P calibrated signal to the CH 2 input. Set the CH 2 switch to .5V/DIV and adjust the variable gain control so that two horizontal divisions are displayed. This procedure will calibrate all switch settings in the XY mode, but remember to reset the CH 2 variable gain control to CAL when returning to the triggered sweep mode.

2-23. CARE OF BATTERIES.

2-24. With proper care, the batteries within the Miniscope will give years of service with little degradation of capacity. To preserve the capacity of the batteries (the ability to retain a full charge), follow the instructions set forth below.

- a. When operating from line voltage, keep the charger plugged into the

- e. Connect an LM-3.5A between TP2 (figure 4-1) and ground.
- f. Adjust R120 (figure 4-1) until multimeter reads +5.75 VDC.
- g. Reduce DC voltage source to +5.70V; front panel LED will go out.
- h. Reading at TP2 should be 0 volts.

4-8. POWER SUPPLY VOLTAGE CHECKS.

- a. Perform tests with batteries charged, fuse in place and charger/transformer connected.
- b. Connect an LM-3.5A as set forth in table 4-1 and read voltages listed.

4-9. ASTIGMATISM

- a. Using the triggered mode and AC input coupling, connect the function generator output to the vertical input. With the generator set to 10 KHz sine wave set the vertical and the time base controls to display two complete sine waves two divisions high.
- b. Adjust INTENSITY (rear panel) control to obtain a bright trace.
- c. Adjust FOCUS (rear panel) control to obtain the clearest and sharpest trace possible. Readjust intensity if needed.
- d. Adjust ASTIGMATISM (rear panel) control so trace has uniform brightness and width in both vertical and horizontal directions.
- e. Repeat steps c. and d. until no further improvement can be made.

4-10. CALIBRATOR

- a. Connect a calibrated oscilloscope from calibrator 1VP-P output, to ground.
- b. Center trace on screen and adjust R129 (figure 4-2) so that calibrator output is exactly 1 VP-P.

4-11. VERTICAL AMPLIFIER BALANCE

- a. Set the trigger mode switch to AUTO. Set the CH 1 input switch to GND. Set vertical V/DIV controls to 50 V/DIV. Set vernier to CAL (CW).
- b. Center trace vertically so it coincides with central horizontal line of graticule using vertical position control.
- c. Change V/DIV controls to .01 V/DIV.

Table 4-1. Power Supply Voltages

VOLTAGE	WHERE MEASURED	CONDITIONS
1. 12.5 VAC (± 0.5 VAC)	Output of 115 VAC charger (inner conductor of plug)	115 VAC 60 Hz input-no load
2. 12.5 VAC (± 0.5 VAC)	Output of 230 VAC charger (inner conductor of plug)	230 VAC 50 Hz input-no load
3. +5.8 VDC to +7.3 VDC	Fuse to ground	Any operating or non-operating mode
4. +5.75 VDC (± 0.05 VDC)	(+) side C32 to ground (figure 4-1)	Any operating mode with batteries charged.
5. -650 VDC to -750 VDC	Pin (1) of CRT to ground	Same as 4
6. +0.50 VDC to +0.65 VDC	Pin (2) to pin (1) of CRT	Same as 4
7. -11.5 VDC to -13.5 VDC	Pin (3) to pin (1) of CRT	Same as 4 with intensity control at minimum
8. +72 VDC to +80 VDC	Junction of R48 & R49 to ground (figure 4-2)	Same as 4
9. +90 VDC to +98 VDC	Junction of R66 & R67 to ground (figure 4-2)	Same as 4
10. +5.0 VDC to +5.4 VDC	Pin (14) of U4 to ground	Same as 4
11. -4.6 VDC to -5.2 VDC	Anode of CR6 to ground	Same as 4

range, .1-1-10-100 (20), vernier, CAL (12) and units, mS- μ S (21) allow sweep times to be varied over an extremely wide range of values. TRIGGER mode is chosen using the trigger select switch, LINE-AUTO-INT-EXT (15).

2-11. TRIGGERED MODES. When a repetitive waveform is connected to VERT INPUT (1) with the triggered mode selected, the vertical controls permit the trace to be started at any vertical point on the trace. Vertical coupling, AC-GND-DC (27) is selected to be either AC or DC. Ground coupling and auto sync is a convenient way to locate the ground reference for DC measurements. The vertical multiplier, 5-2-1 (2), range, .01-.1-1-10 (3) and vernier, CAL (5) controls are used to adjust the height of the trace. One division minimum is required for operation in the triggered mode. Maximum vertical input voltage is 350 volts peak. Input impedance is one megohm shunted by 50 pF.

2-12. The SLOPE (13) control is used to choose whether the trace will start on the positive- or negative-going side of the waveform. Using the sync LEVEL (14) control, the trace can then be started at any point on the side which has been chosen.

2-13. AUTOMATIC TRIGGERING. In the auto trigger mode, the sweep free runs at the rate selected by the time base switches. This provides an uninterrupted trace for non-repetitive waveforms. It is utilized for DC voltage measurements. In the absence of a vertical input the trace represents zero amplitude. In the auto mode, synchronizing is usually not possible for repetitive waveforms as it is in the triggered modes.

2-14. LINE SYNCHRONIZATION. In the LINE triggered mode, the line frequency is used to trigger the sweep. The LINE mode provides very positive synchronization for input waveforms which are derived from and consequently synchronized to the line frequency.

2-15. EXTERNAL TRIGGERING. Trigger waveforms from any external source of one volt or more may be connected to the Miniscope by means of the TRIG INPUT jack (19).

2-16. Using an external trigger, an input waveform can be synchronized to itself. Consequently, it provides very positive synchronizing and for non-repetitive or transient waveforms, it is especially useful and provides better results than the other trigger modes in this regard. In clocked equipment, with the clock used as an external trigger, both AC and DC amplitude measurements can be made rapidly with a minimum of control adjustments.

NOTES:

1. U3, U4, U5, U6, U8, U9, U10, U13:

PIN 14 TIES TO +5V

2. U8, U9, U10, U13: PIN 7 TIES TO -5V

3. U3, U4, U5, U6: PIN 7 TIES TO GND

4. U7: PIN 1 TIES TO +5V; PIN 8 TIES TO -5V

5. U14: PIN 1G TIES TO +5V; PIN 8 TIES TO -5V

6. CONTROL P.C. BOARD: 41-164

MAIN P.C. BOARD: 41-166

POWER SUPPLY P.C. BOARD: 41-168

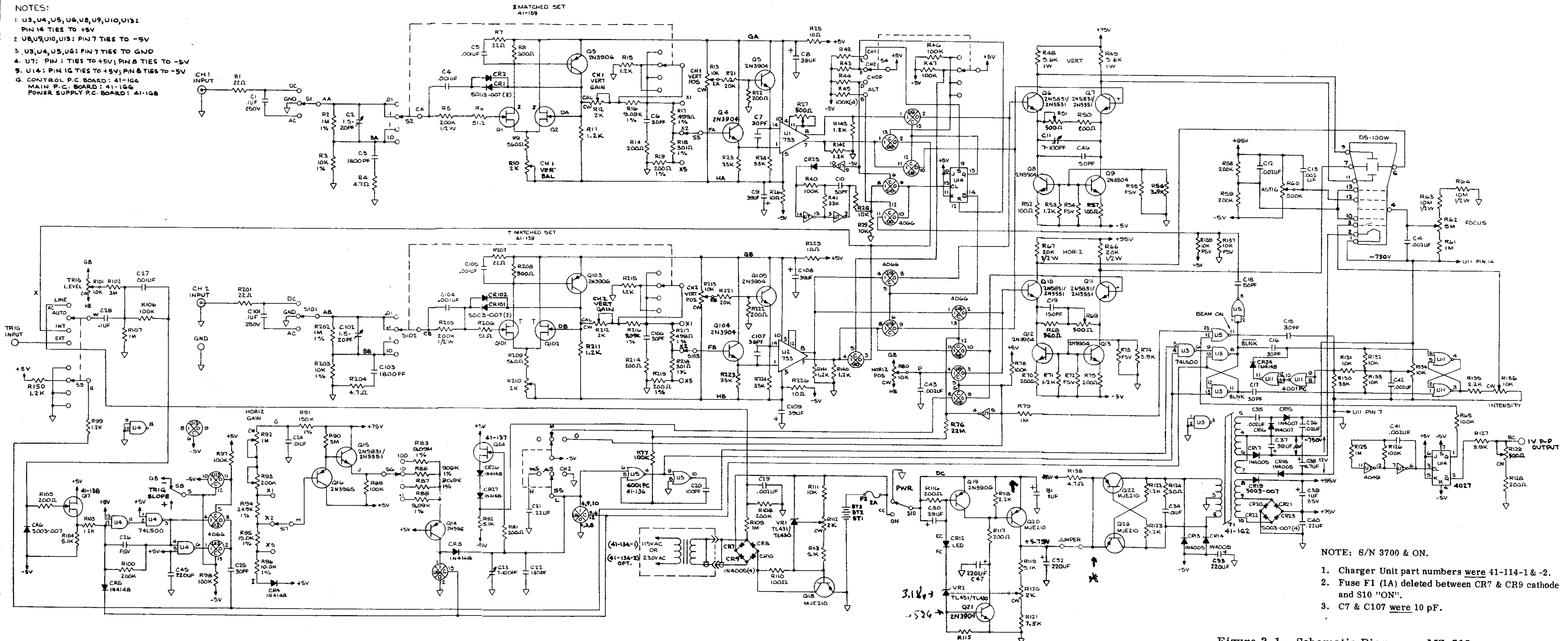


Figure 3-1. Schematic Diagram - MS-215